1973

Biomass and Nutrients in Desert Shrub Ecosystems

James O. Klemmedson

Edwin L. Smith

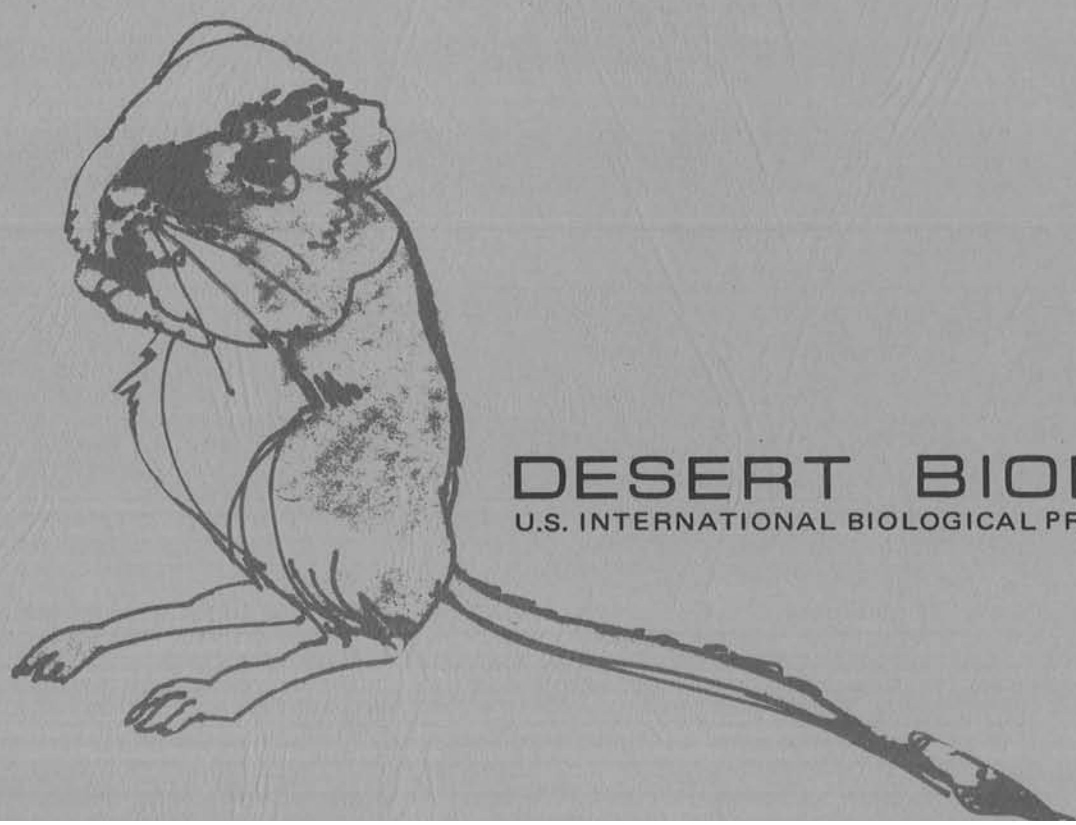
IBP

RESEARCH MEMORANDUM

RM 73-8

BIOMASS AND NUTRIENTS IN DESERT SHRUB ECOSYSTEMS

James O. Klemmedson and Edwin L. Smith



DESERT BIOME
U.S. INTERNATIONAL BIOLOGICAL PROGRAM

1972 PROGRESS REPORT

BIOMASS AND NUTRIENTS IN DESERT SHRUB ECOSYSTEMS

James O. Klemmedson, Project Leader

and

Edwin L. Smith

University of Arizona

Research Memorandum, RM 73-8

MAY 1973

ABSTRACT

In the second year of a study to measure distribution of biomass and nutrients in shrub ecosystems as a function of shrub age, season and environmental variables, fifteen shrubs each of mesquite (*Prosopis juliflora*) and palo verde (*Cercidium floridum*) were sampled. Seasonal patterns of change in percentage N of leaves in mesquite and palo verde were observed and appear real. Additional sampling is needed to confirm these changes and to determine if suspected concurrent changes in N of small branches reflecting translocation is real. Nitrogen content of mulch of the overstory shrub appears not to vary spatially under the shrub, but that of understory species does. The understory species may be acting as a bioassay of variable soil N content with distance away from the stem of the shrub.

Although 11 percent of N in the above-ground phytomass of mesquite is contained in the annual plant parts and is therefore subject to seasonal variation, N in the above-ground portion of mesquite is highly correlated with phytomass. The opportunity to extend this relationship and estimate N and C fixed in these ecosystems from mensurational characteristics of the shrubs appears good. Special effort will be devoted to exploration of these relationships during the third year of the project.

INTRODUCTION

A study of seasonal and annual changes in the distribution and balance of biomass and nutrients in mesquite (*Prosopis juliflora*) ecosystems was initiated in 1971 at the Santa Rita Experimental Range. The study was expanded in 1972 to include palo verde (*Cercidium floridum*) at the Santa Rita site, and to sample mesquite on a limited basis at the Jornada Experimental Range in New Mexico. Five shrubs each of the two species were sampled on each of three phenological dates; three shrubs of mesquite were sampled at the Jornada site in August. Twice as many samples of palo verde were collected as we had originally expected to collect. Although the field work was accomplished on schedule and with improved efficiency over the previous year, laboratory work has been delayed because of the increased number of samples for analysis. In 1973, we anticipate that information gained during the first 2 years of the study will permit us to refine our sampling techniques and reduce the laboratory work.

OBJECTIVES

The objectives of this study are to measure the distribution and balance of biomass and nutrients (carbon and nitrogen) in the regime of important desert shrub ecosystems, specifically mesquite (*Prosopis juliflora*) and palo verde (*Cercidium floridum*).

Specific objectives are:

1. To determine the influence of shrub age on distribution of biomass, and on distribution and balance of nutrients in individual shrub ecosystems.
2. To measure seasonal changes in biomass, and in distribution and balance of nutrients in individual shrub ecosystems.
3. To determine the effect of macro-environmental factors (precipitation, temperature, radiation), which vary yearly, on increment of biomass and nutrient distribution.

METHODS

Size data of shrubs (DSCODE A3UKB01) were accumulated by measurements collected three times yearly on five randomly-selected shrubs of each species, representing the population of size classes available. Above-ground biomass of shrubs (DSCODE A3UKB02) was determined through collections made three times yearly on five randomly-selected shrubs of each species, representing the population of size classes available. Weight was obtained to determine biomass/shrub. Samples were prepared for laboratory analysis.

Collections of root biomass associated with shrubs (DSCODE A3UKB03) were made three times yearly from five randomly-selected shrubs of each species, representing the population of size classes available. Weight was taken to determine biomass/unit volume. Samples were prepared for laboratory analysis.

Collections of understory vegetation of shrubs (DSCODE A3UKB04) were made three times yearly under five randomly-selected shrubs of each species, representing the population of size classes available. Standing dead and live material were separated and weighed to determine weight/unit area, then prepared for laboratory analysis.

Collections of mulch under shrubs (DSCODE A3UKB05) were made three times yearly under five randomly-selected shrubs of each shrub, representing the population of size classes available. Mulch of mesquite and other vegetation was separated and weighed to determine weight/unit area, then prepared for laboratory analysis.

Analyses for total nitrogen by the Kjeldahl method (Bremmer, 1965) and for organic carbon by the dry combustion method (Allison, Bollen and Moodie, 1965) using a LECO high-frequency induction furnace, were run on above-ground biomass (DSCODE A3UKB06), understory species (DSCODE A3UKB07), mulch (DSCODE A3UKB08) and soil (DSCODE A3UKB09).

RESULTS AND DISCUSSION

Results of second-year sampling for nutrient content of plant parts of mesquite (Table 1) give us no reason to alter earlier observations (Klemmedson and Smith, 1972) regarding nitrogen content of plant parts and variations as a function of sampling period. Seasonal trends in N content of leaves, current branches, and perhaps branches less than 1 cm diameter, appear to be real and to have biological significance. Bi-weekly sampling was initiated in May to gain more information on the trend of N content in leaves and current branches. The data for leaves of mesquite and palo verde (Figure 1) show a fluctuating pattern for percentage leaf N between the periods of leaf initiation in the spring and the summer rainy period, followed by a steady decline into fall and winter periods. Further analyses are needed to determine if the spring and summer fluctuations are associated with precipitation patterns. The fall decline is likely a combination of translocation and losses by leaching and/or oxidation.

Seasonal differences in N content of larger branches (> 1 cm) and dead wood are difficult to rationalize biologically and must be attributed to sampling variation at

Table 1. Percentage nitrogen in plant parts of mesquite and palo verde by seasons

Plant Part	Mesquite 5-71††	9-71	2-72	5-72	Palo Verde 2-72	5-72	Significance of Differences
	-------	-------	-------	%	-------	-------	
Flowers	3.67†	----	----	3.16	----	3.35	
Fruit	----	----	----	4.70	----	3.55	
Leaves	3.30	2.83	2.25	3.09	----	3.94	*
Current Branches	2.28	1.98	2.15	1.95	2.56	3.08	*
Branches < 1 cm	1.20	1.54	1.78	1.58	1.61	1.62	
Branches > 1 cm	1.09	1.34	1.14	1.12	.76	1.25	
Dead Wood	.83	1.00	.98	1.15	.90	0.86	*

*Species difference significant at $\alpha = .05$; other species differences were non-significant.

†Except for flowers and fruit, all values are means of five samples.

††Month and year.

Table 2. Distribution of nitrogen in above-ground phytomass of mesquite

Year & Season	Leaves	Flowers	Fruit	Branches Current	Branches <1cm	Branches >1cm	Dead Wood
	-------	-------	-------	%	-------	-------	-------
1971 Spring	17.8	0.3	----	0.1	21.4	38.7	21.1
Fall	6.8	---	----	0.6	21.9	45.6	19.4
1972 Winter	1.0	---	----	1.0	29.5	45.9	22.3
Spring	10.8	0.1	0.4	0.7	13.7	49.4	25.0
Mean	10.6	0.1	<.01	0.6	21.7	44.9	22.0

this time. Paired t-tests show that leaves and current growth of palo verde were significantly higher in the spring of the year than those of mesquite (Table 1). Data in Figure 1 suggest this difference is maintained throughout the year. The significant difference in N content of dead wood for the May 1972 sampling period is highly suspect for reasons given above. Fruit were produced on both mesquite and palo verde this year, yielding high but extremely variable N content between plants.

Data for 20 shrubs show that N in the above-ground phytomass of mesquite is largely tied up in woody tissues. For the average-size mesquite shrub sampled, about 11 percent (approximately 60g) of the N in above-ground phytomass was contained in leaves, flowers and fruit (Table 2). Even so, this is about twice the amount of

N contained in similar plant parts in 50-year-old pole size ponderosa pine (Welch, 1973). The relatively high percentage of N contained in these annual plant parts can be attributed both to the amount of tissue, relative to total phytomass, and to the high percentage of N content of the tissues.

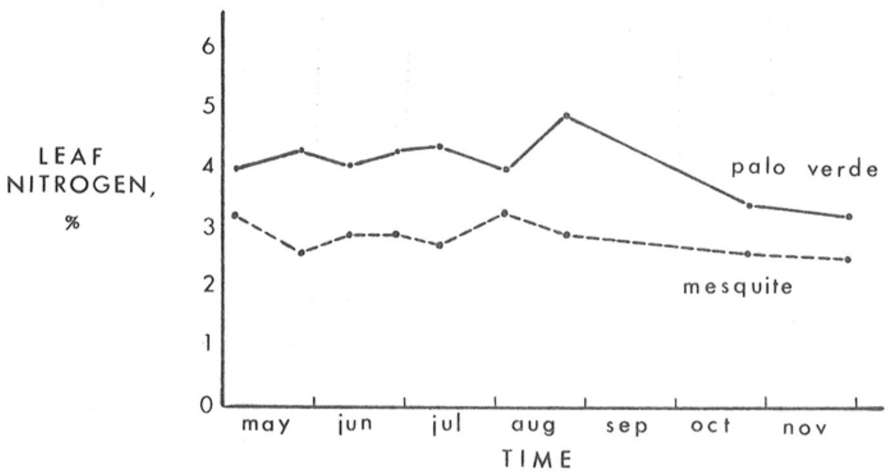


Figure 1. Percentage nitrogen in leaves of mesquite and palo verde as a function of time (DSCODE A3UKB06).

Because of the annual and seasonal differences in percentage N of plant parts which appear to be showing up (Table 1), the percentage distribution of N can be expected to vary also with season. Real trends in distribution of N are suggested for leaves, current branches, and perhaps for branches less than 1 cm diameter (Table 2), even if we account for the fact that these data are not adjusted for differences in shrub size. Because each value in the table is the mean of only five shrubs sampled at random within size class, part of the variation must be attributed to sampling variation.

Despite the fact that concentration of N in plant parts varies from shrub to shrub and at least 11 percent of the N in above-ground phytomass may be subject to seasonal fluctuations, the quantity of N in the phytomass is highly correlated with above-ground phytomass as shown by the regression in Figure 2. This suggests that good estimates of N in the phytomass can be made if the above-ground phytomass is known. A similar regression equation ($Y = -.109 + 0.413\ X$, where Y is kilograms of carbon and X is kilograms of phytomass) can be used to estimate the amount of carbon fixed in mesquite shrubs. Since carbon in plant tissues is quite stable, it is not surprising that the correlation coefficient is near 1.0 (r = .99). If a regression between some mensurational characteristic of shrubs and their phytomass could be developed with high predictability, much of the tedium of field and laboratory work could be eliminated in determining the quantity of N and C tied up in shrub ecosystems.

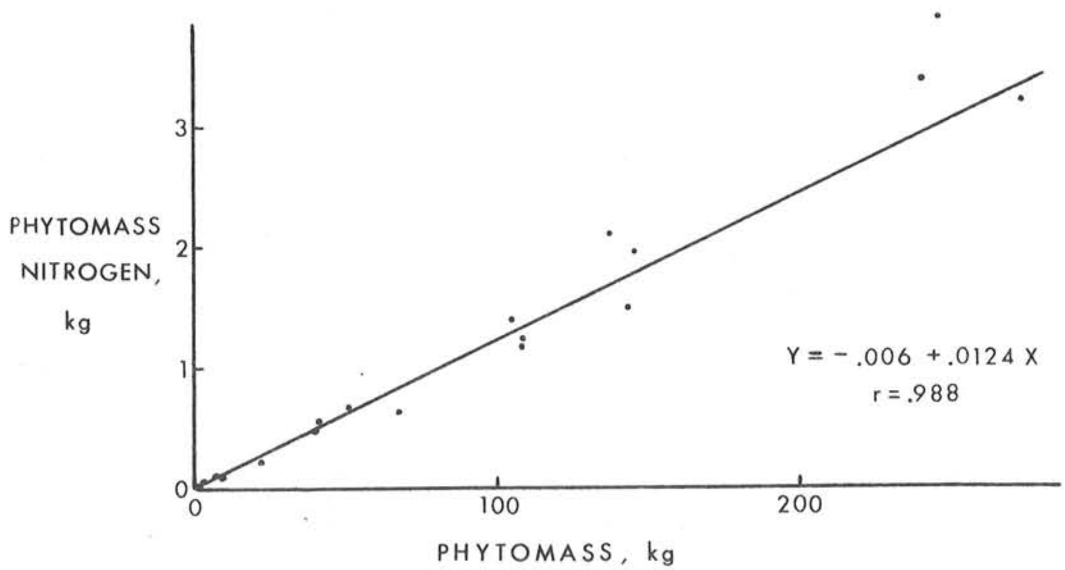


Figure 2. Quantity of nitrogen in the above-ground phytomass of mesquite as a function of phytomass (DSCODE A3UKB06).

The depth function of percentage soil N for the mean of ten mesquite shrubs (Figure 3) is expected from data presented last year showing decreasing amount of N in mulch with distance away from the shrub center (i.e. impact of mulch chemistry should be expressed in the soil). The trend for soil carbon is similar. The influence of canopy position is greatest in the surface 5 cm and decreases with depth. With distance away from the center of the shrub, the decline in percentage N with depth deminishes. The significance of difference between canopy positions, particularly at the 30-60 cm depth, is uncertain. As this pool of data increases, analyses will be performed to determine the effect of shrub size on shape and position of the depth function for each canopy position. An hypothesis for current investigations is that depth function for N and C may be predictable from shrub size and mulch characteristics. If this hypothesis is true, we should be able to greatly simplify soil sampling during 1973.

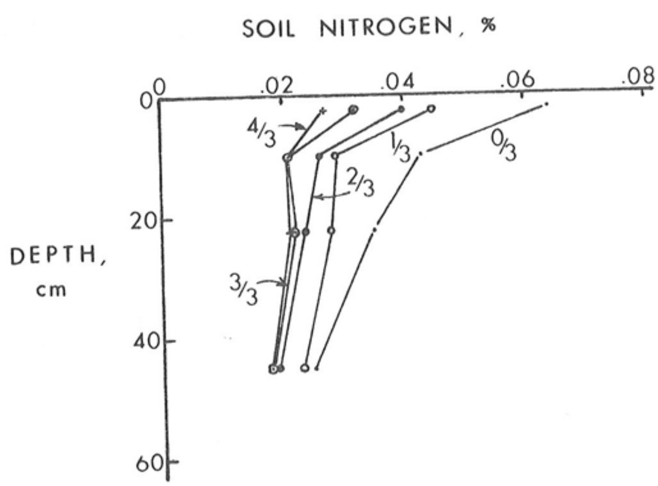


Figure 3. Soil nitrogen as a function of depth and canopy position (i.e. distance from stem to canopy edge). DSCODE A3UKB09.

Table 3. Percentage nitrogen in mulch of mesquite and palo verde ecosystems as a function of species of mulch and canopy position

Species of mulch	Distance from Stem to Canopy Edge			
	1/3	2/3	3/3	4/3
	----------	----------	----------	----------
Mesquite	1.61	1.59	1.55	1.58
other spp.	1.31	1.28	1.13	0.87
Palo verde	1.13	1.27	1.22	1.33
other spp.	1.18	1.07	1.05	0.84

Limited data in last year's progress report suggested a possible trend in percentage N of mulch (both for mesquite and other species) as a function of canopy position. Additional data, although not subjected to statistical analysis as yet, suggest that canopy position has no effect on percentage N of mulch from the shrub (either mesquite or palo verde), but that mulch of other species (understory shrubs, herbs and succulents) is higher in nitrogen near the shrub center and declines with distance away from the shrub (Table 3). This effect is apparent for both mesquite and palo verde. It suggests that understory vegetation is acting as a bioassay of soil N conditions under the shrubs, and that the effect is still measurable in the mulch. If so, it confirms the observation of higher soil N under mesquite noted here and elsewhere (Tiedemann and Klemmedson, 1973a) and it's higher availability to plants (Tiedemann and Klemmedson, 1973b). Although species differences have not been tested, the data suggest that mulch associated with mesquite is higher in percentage N than that associated with palo verde; a surprising though unconfirmed result in view of data in Table 1 and Figure 1.

EXPECTATIONS

Work during the calendar year 1973 will proceed with approximately the same sampling objectives as those for the past year. However, we recognize the need to lighten the load of laboratory work which we encountered the past year by adding palo verde to the study. We feel there are good opportunities to reduce the field and laboratory work without sacrificing the intensity of sampling appreciably. There is a good possibility of reducing the soil sampling if depth functions for N and C can be developed with sufficient precision that we can predict with reliability the nutrient content of lower soil layers from the 5-15 cm value. The opportunity for this appears promising. Similar techniques will be examined to refine the determination of biomass. Development of these relations will not only improve the efficiency of this project, but provide methodology for estimating distribution of nutrients and biomass on an areal basis. If these economies in sampling and analysis can be achieved, we stand a chance to include in the 1973 program the chemical analysis of mesquite and palo verde on the Silverbell site and perhaps other species of interest to the Biome project.

LITERATURE CITED

Allison, F.E., W.B. Bollen, and C.D. Moddie. 1965. Total carbon. In: C.A. Black (Ed). Methods of soil analysis. Agronomy No. 9, Part II, Amer. Soc. Agron. p.1346-1366.

Bremner, J.M. 1965. Total nitrogen. In: C.A. Black (Ed). Methods of soil analysis. Agronomy No. 9, Part II, Amer. Soc. Agron. p. 1149-1179.

Klemmedson, James O., and Edwin L. Smith. 1972. Distribution and balance of biomass and nutrients in desert shrub ecosystems. U.S./IBP Desert Biome Res. Memorandum RM 72-14.

Tiedemann, Arthur R. and James O. Klemmedson. 1973a. Effect of mesquite (*Prosopis juliflora*) on physical and chemical properties of the soil. J. Range Manage. 26:(in press).

Tiedemann, Arthur R. and James O. Klemmedson. 1973b. Nutrient availability in desert grassland soils under mesquite (*Prosopis juliflora*) trees and adjacent open areas. Soil Sci. Soc. Amer. Proc. 37:(in press).

Welch, Tommy G. 1973. Distribution of nitrogen and carbon in ponderosa pine ecosystems as a function of parent material. Ph.D. Dissertation, University of Arizona Library.